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ABSTRACT

Observational techniques were employed to gain insights into students' experiences from three perspectives (learner, teacher, and observer) as related to four aspects of a set task (nature of the task, including its purpose; how the task was carried out; perceived significance of outcomes achieved; and significance of outcomes in terms of science learning/teaching). Extracts and examples from 16 lessons (analyzed) in depth) are presented to exemplify aspects of science lessons identified as problems associated with these experiences, and to point to reasons why children do not significantly alter their perceptions about how and why things behave as they do. One group of factors which appeared to lessen the likelihood of students appreciating the significance of a task was an observed tendency on the part of some students to see the task in isolation. Because of this tendency, they failed to set the present experience against other related experiences. In addition, it was found that some students were unable to effect design requirements of a task and ended up carrying out alternative tasks. These and other factors (including those linked to students' cognitive structures) indicate how different students' experiences can be from those intended by teachers and curriculum developers. (JN)

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CHILDREN'S VIEWS AND CLASSROOM EXPERIENCES

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WORKING PAPER 43

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Paper presented to the
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Massey,
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Introduction

Recent work of Osborne (1980), Osborne and Stead (1980a, 1980b) and Stead (1980a, 1980b) at the University of Waikato have re-emphasised that children at quite a young age, and before they are taught science, construct out of their everyday experiences views which they use to explain their world. Of particular interest, is that not only have they been able to identify and describe these intuitive views for a range of specific phenomena, but also they have established that such views can be remarkably persistent. Osborne (1980), for example, found that views of some first-year University Physics students of force remained essentially those of much younger children, rather than those of a scientist, in spite of a background of experiences which included five years of apparently successful involvement in secondary school science. That intuitive views are held by young children is not surprising, what does raise questions is how such views continue to be held in spite of classroom experiences specifically aimed at establishing the concensus science viewpoint.

This paper is developed out of work carried out to inquire into the nature of children's classroom experiences; work which has involved close observation of 11 to 14 years old children at work in typical Forms 1-4 science lessons. Of special interest was to establish what these children say, do, and think about while they carry out experimental investigations. This particular focus was chosen because science teachers have been, through a great range of curricula materials[1], encouraged to develop programmes which are centred in such pupil tasks. Furthermore, it seems likely that science programmes based on pupil involvement in investigations have been little studied. Kornhauser (1979) states that "in spite of the widespread adoption of the guided discovery approach in science teaching, it has so far only attracted little attention by researchers, and examples of research of direct value for the practicing teacher are relatively rare (e.g. Hodson, 1975)".

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1 Including the 1978 Forms 1-4 Science: Draft Syllabus and Guide of the New Zealand Department of Education.

Observational and Analytical Methodologies

The classroom observations have been made against a background of other less sensitive contacts with both pupils and teachers (e.g. individual interviews outside the classroom). Once in a classroom the observer employed a set of behaviours which have been developed to provide a comprehensive account of what happens in classrooms, particularly in terms of the learner, with a minimum of obtrusion[1]. The observation was guided by a framework (see, Tasker and Osborne, 1980) which not only ensures a record of classroom action and dialogue describing the task set and the interaction with it of the learner, but also provides comments from both learner and teacher which give insights into their perceptions of the task and the learners' response to it. The lesson-records which eventuate from the transcription, annotation and collation of the data collected, have been analysed using this same framework. Thus it has been possible to consider the experience of the learner from three perspectives (learner, teacher and observer) and in relation to four aspects of the set task;

- the nature of the set task (including purpose)
- how the task was carried out
- the perceived significance of the outcomes achieved, and
- the significance of outcomes in terms of science learning and teaching.

A large number of lessons in a wide range of classrooms have been observed. Sixteen of these, involving nine teachers and all Form 1-4 levels, have been analysed in depth and provide the data and examples on which this paper is based.

The analysis established the nature of the twelve categories described above to an extent which has allowed comparisons to be made both across the three perspectives and between the four task levels. Issues related to children's science classroom experiences have emerged, a number of which are pertinent to the possible reasons why children's views are sometimes not influenced by classroom experiences. It is these issues which form the focus of this paper.

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1 A Procedures Checklist for the Participant Observer is available from the author.

Problem Aspects

In this section extracts and examples from the sixteen lessons analysed in depth, are used to exemplify aspects of science lessons which have been identified as problems associated with children's classroom experiences, and which point to reasons why children do not significantly alter their perceptions about how and why things behave as they do. It has been possible to do this only because the teachers concerned were willing that this be so.

a. There are problems with the lesson being one part of a series of lessons

Lessons are perceived by pupils as isolated events while to the teacher they are parts of a related series of experiences.

Any single science lesson tends to be part of a series of lessons which form the classroom programme for a particular topic. As such, they are viewed by science curriculum writers and science teachers as providing not only a particular experience for pupils and a specific influence on their views, but also as contributing to a set of related experiences designed to have a collective influence. Unfortunately, this broader perception of a single lesson is not recognised by some children.

The following extracts come from a lesson concerned with the 'effect of heat on the rate of dissolving'. The task set to inquire into this, involved pupils dropping crystals of potassium permanganate into water of different temperatures and noting what happened.

Teacher perceptions relating to the lesson

T to observer: "This is the third lesson in a series aimed at developing a particle idea and going over states of matter ... the first one (lesson) we did was also to do with this. It was to do with expansion and contraction of substances - today was a direct follow on from that."

Pupils perceptions relating to the lesson

O: "What was today's one all about?"

P: "What crystals can do ... we get a card every-so-often (a work card) and we copy from the card. Do an experiment, maybe with crystals."

O: "Does today's work have anything to do with this other work you've been doing? (pointing to the pupils open exercise book which was showing notes headed up as the 'dilution of a potassium permanganate crystal' and 'heating and expanding liquids')."

P: "No, not really ... no."

This narrow focus of some pupils is of significance for teachers who draw heavily on previous classroom experiences when setting the scene for a task at hand (see Appendix A(i)). Links which a teacher perceives as strong and obvious, especially if they relate to the scientific ideas taught in previous lessons rather than to what pupils did or what happened, may be far from obvious to pupils whose concern is with what they will have to do today. Another aspect of this problem is that teachers refer to the past in terms of their own perceptions and unfortunately, as will be described later in the paper (see (e)), these perceptions are often not those of their pupils.

b. <u>The lesson has a purpose</u>

The pupil perceived purpose for the task is not the teacher perceived purpose for the task.

It has not been uncommon (in nine out of sixteen lessons) to find that the teacher's perceptions regarding the purpose of a set task have not been matched by the perceptions of the pupils regarding the purpose of the task. A range of factors appear to have operated to bring about this state of affairs in the lessons observed.

In four lessons, the problem appeared to have been the failure on the part of pupils to recognise the purpose, in the sense that although the teacher purpose was made explicit, either verbally or in written form, pupils nevertheless established an alternative purpose for the task.

P "He talked about it ... That's about all ..."

O "What have you decided it (the task) is about?"

P "I dunno, I never really thought about it ... just doing it - doing what it says ... its 8.5 ... just got to do different numbers and the next one we have to do is this (points in text to 8.6)."

On four other occasions, when the explicit purpose stated <u>was</u> recognised by pupils, discussion with the teacher revealed that this 'public' purpose was, in fact, not the actual purpose for the task. The real purpose, for some reason, was never stated and remained 'private' to the teacher.

Example: A classroom of 3rd formers are following up a lesson in which they had established a heating curve for tapwater by establishing a similar curve for saltwater.

(i) Teacher's 'public' purpose

T to class "Right we'll do precisely what we did yesterday - somebody asked 'can we put the results on the same graph that you did for homework (the graph obtained from heating tapwater)' - certainly you can do that as what we are trying to do (today) is compare them isn't it?"

(ii) Pupils' purpose

O (joining a group of three boys) "This looks interesting".

P_1 "Yeah, we have to ... fill the beaker to 150 ... then um ... get 5ml of salt, then we put it in here (indicating the beaker of water) and them we put it on there (touching the gauze on the tripod) - then we have to take the heat."

O "I see and what's it all about?"

P_1 I dunno - we just have to do it and get the graph."

(iii) Teacher's 'private' purpose

T to observer "We needed to use the bunsen the other day and I found some students had never used them, so we digressed from our programme to do something which would develop the skill of using a bunsen - also using a thermometer and we can draw a graph ... We did this (same procedure) yesterday with tapwater and someone said 'I thought water boiled at 100^{o} - so today we are trying heating water with salt and other things in it - reinforcing the skills really."

In the remaining instance only instructions for carrying out the task were initially given. A purpose for the task being publicly stated by the teacher, only after pupils had carried it out simply by following the instructions.

Following instructions, in fact, appeared to be the common 'purpose' assigned to science tasks by pupils unable or not concerned to perceive a scientific purpose. This is not surprising perhaps, since it leads to actions which are expected by the teacher and is therefore an effective coping stategy. The other purpose which pupils assigned when unable to identify a science purpose, occurred when pupils considered they knew the

expected outcome; the task then became 'get the right answer' (see Appendix B for an example). The problem with the first of these strategies is that the outcome accepted by pupils can be other than that expected by the teacher, in spite of the teachers' expected outcome being achieved. While the problem with the second approach indicated is that pupils tend to ignore good scientific habits, such as being systematic and thinking critically, and simply use any practice which will achieve the perceived goal (see Appendix B (i)).

The tendency for pupils to construct as a purpose for a scientific classroom task either 'following the set instructions' or 'get the right answer' may be especially associated with individualised programmes, since it was in classrooms organised on this basis that this practice was particularly apparent.

c. <u>The experiment is designed with the purpose in mind</u>

Pupils perceptions of the nature of the task do not include critical scientific features but teachers assume they do.

To the teacher[1] and curriculum writer the features of the various investigative tasks employed in science lessons are clear and designed to elucidate particular aspects of interest: such people have a 'feel' for the task itself and the nature of the outcome to expect. Pupils, on the other hand often have little or almost no feeling whatsoever for features in the design of an investigation (see Appendix B) and consequently little appreciation of what to expect in the way of outcomes. Unfortunately, teachers did not often sense this mismatch or at least it was very rare (only once in sixteen lessons) for them to <u>explain</u> the nature of an investigation; they gave instructions which contained design features but almost never it seemed to the observer, elaborated on its significance (see Appendix A (iv)). The effect of this lack of feeling in pupils for what they were doing was to greatly enhance the likelihood of a compromise in a design feature of an investigation and/or the acceptance of secondary outcomes as the significant outcomes (see Appendix A (iii) and (iv) and Appendix B).

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1 Teachers with little background in science sometimes appeared to lack this appreciation.

An associated factor to the state of affairs described above, was an apparent lack of familiarity on the part of some students with some items of equipment and materials involved in the investigations observed. For example, pupils had their own views about bimetallic strips,

O "Why do you think the strip bends that way?"

P "The metal must have been made in one way."

O "Is the strip made up of just one type of metal?"

P "No, the handle is different."

and have talked of sulphur coalphate and Condor's crystals. Furthermore, pupils have lacked skills required to achieve some design features expected, e.g. pupils required to measure out 10mls of water showed no apprecation of how to cope with the curved miniscus effect and no awareness of parallax error, their 'measured' 10mls actually ranged from 7mls to 12mls.

It was in these situations that pupils tended to indulge in off-task action and there seemed to be an obvious message for teachers. Preparation of pupils for experimental investigation through the provision of opportunities to handle equipment, practice skills, and consider design features of experiments seems clearly warranted. What seems required are lessons aimed at specific skills and involving particular equipment where the emphasis is on what the pupils are doing and what immediate outcomes are being obtained, rather than on the scientific significance of those or other expected outcomes.

d. <u>There are other cognitive problems in carrying out the task</u>

The actual cognitive structures of pupils against which actions and outcomes of investigative tasks are considered are not the teacher assumed structures.

In all lessons observed, teachers made assumptions regarding the views pupils held in relation to phenomena associated with the task which were unjustified for at least some pupils. The economics of the classroom and the syllabus may demand the making of assumptions. However what seemed clear, was that the extent and nature of these assumptions

were not appreciated by teachers. The examples cited below are included because in the context of the various lessons they had a marked influence on the nature of the classroom experience.

(i) pupils lack assumed prerequisite knowledge.

The following comment has been extracted from the lesson-record 'properties of oxygen' where two fourth formers were using oxygen produced by heating a small amount of potassium permanganate in a test-tube, to establish whether or not oxygen smelled or supported combustion. Unfortunately, there was dust in the crystals and the test-tube had only a small volume.

P "(wafting gas towards his nose by waving his hand across the top of the test-tube which had just been removed from the heat) It smells like burnt fluff ... stinks" (writes 'smells strongly' in notes).

(They light a splint and after reheating the test-tube hold the splint in the test-tube - it burns briefly then goes out.)

O "What are you testing now?"

P "Does it support combustion."

O "And what have you decided?"

P "Oxygen kills the flame."

It was perhaps in examples of this kind where the isolation of the science classroom and what happens there from the real world of the learner was most obvious. Perceptions which did not fit any aspect of an individual pupil's integrated cognitive framework appeared to be accepted with seemingly little impact, perhaps as Gilbert et. al. (1980) have commented, into a secondary cognitive structure established solely for use in formal science situations - or ignored. What these kinds of observations suggested, was that some pupils were drawing heavily upon this secondary framework in the science classroom but only rarely tapping their main framework.

(ii) pupils are unable to grasp the 'mental set' required.

Sometimes the classroom experience of a pupil was considerably influenced by an intuitive view he or she held without the teacher being aware. To illustrate this problem extracts are presented from the lesson-record 'Properties of oxygen' where the intuitive viewpoint 'if you can't see it then it doesn't exist' (Osborne and Gilbert, 1980) was a key determinant in what pupils took from that classroom experience.

T "Simply heat the potassium permanganate in the flame and it produces oxygen" (demonstrates)

P "There's nothing there" (not being able to see the colourless gas)

and later, after the pupil has carried out the task.

O "Have you decided whether it supports combustion or not?"

P "It doesn't ... because when we put that (the lighted splint) in there (in the test-tube) it doesn't burn."

O "What does the 'it' refer to?"

P "I suppose it means that stuff (pointing to the potassium permanganate crystals)."

O "Finished?"

P "Yeah."

O "Was it all right?"

P "Pretty clear."

e. <u>Significance of outcomes in terms of influence on children's views of the world</u>

The pupils' perceptions relating to the significance of task outcomes achieved are not those the teacher assumes are perceived.

As has been illustrated in previous parts of this section, many factors operated to influence just what pupils recognised as the significant outcomes from their involvement with a classroom scence task. All of the factors identified naturally reduce the influence of the classroom experience on the child's viewpoint.

One group of factors which appeared to lessen the likelihood of pupils appreciating the significance of a task, was an observed tendency on the part of some pupils to see the task in isolation and as a consequence they failed to set the present experience against other related experiences (see (a)). Other factors, influenced the perceptions of pupils regarding the purpose of the investigative tasks set and often resulted in pupils establishing purposes for the task other than those intended by the teacher or curriculum writer. Where this happened, pupils tended not to have the expected experience and consequently appeared little affected in terms of the views they held for the phenomenon involved (see (b)).

However, being on the same wavelength as the teacher was still not enough to ensure that a pupil had the expected experience. A number of pupils, as a result of a lack of feeling for the scientific features of a task and/or skill deficiencies were unable to effect the design requirements of a task and ended up carrying out alternative tasks (see (c)). Finally, there were factors linked to the cognitive structures pupils' appeared to possess and apply to the task that resulted in interpretations other than those expected (see (d)). What makes science teaching based on pupil involvement with investigative tasks so difficult is that any one factor is often sufficient to prevent pupils having the expected experience.

However, even in situations where pupils appreciated the;

- lesson was related to proceeding lessons,
- the teacher's purpose for the task,
- the design features of the task, and
- the various phenomena associated with the task,

they still did not necessarily have their child's viewpoint influenced in the way intended by the teacher or curriculum writer. For example, the results in some experiments were not always those that a scientist would have predicted and hence the influence of those experiences was not in the direction intended. More importantly the observations suggested that neither support of the pupils achievement in obtaining an answer, nor careful distinction and isolation of that answer from the scientific answer, is often made.

Summary

That pupils retain intuitive views of the world in spite of science classroom experiences designed to teach the consensus science viewpoint was the stimulus for a classroom-based research study. What became apparent from sitting with pupils while they carried out investigative tasks in science lessons, was how different the pupil experience can be from that intended by the teacher and curriculum writer. The basis of this mismatch has been explored in terms of three perspectives - pupils, teacher and observer, and by applying a grounded theory approach to the analysis of the lesson-records. Teachers and curriculum writers have tended to view investigative tasks largely from their own perspective - the findings of this work suggest that this practice has encouraged a spectrum of assumptions regarding the learner's response that may well be unjustified.

Acknowledgement

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APPENDIX A: An outline of a Lesson

The class: The following extracts have been taken from the lesson-record of a Form 1 class (11 year-olds). The class is organised into six groups each of five pupils. The comments on the lesson come from the observer's perceptions of the action's, dialogue and comments of both the teacher and the group of pupils with whom the observer sat.

The task: This was written on the blackboard as below:

Expansion of a Liquid

Method: Fill the flask with coloured water.
Mark the level of the water in the tube.
Heat the flask using a burner.

Observe what happens to the water level.

Explain why this happens by talking about particles.

Observer's Note: The stoppers supplied were different from that drawn. Those supplied had a shorter length of glass tubing to which was attached a length of clear plastic tubing.

(i) There are a series of lessons.

This lesson was one of a series of lessons considering the nature of matter. In the immediately preceeding lesson the pupils had investigated crystallisation. At the end of that lesson pupils had been encouraged by the teacher to try and grow salt (NaCl) crystals at home.

The task of the lesson was identified - "todays work is on the board" (see above) but not explained by the teacher who then referred to the homework task in an attempt to develop a class discussion on particle behvaiour associated with crystallisation - a discussion perceived by the teacher as orientating pupil thinking for the task to come. However, it seems unlikely that the pupil perceptions relating to their crystallisation experience matched those of the teacher.

T "Don't forget when you try to grow crystals at home to use hot water to dissolve the salt ... when you are dissolving salt what does heat help to do?"

P_1 "Dissolve it."

T "Right, it helps to dissolve it ... what happens when we dissolve a solid in a liquid? Can anyone explain what happens to the particles?"

P_2 "The solid will melt its way into the liquid."

T "It melts its way."

P_4 "Oh ... evaporates away."

T "Well if its the liquid - it's not going into a gas it's going into a solution isn't it ... well it can't evaporate ... can anyone explain what is happening when crystals are forming?"

P_5 "The water is cooling down."

T "Right, the water is cooling down - particles are slowing down and they are being attracted back into a solid aren't they ... now would one person in the group come up and get a drop of food colouring ..."

(ii) <u>The lesson has a purpose</u>

For the teacher the purpose of the lesson was clear - it was concerned with particle behaviour.

T to class "Today we are looking at solutions and what happens to solutions when we apply heat to them ... now can anyone tell me what they think might happen to particles in the solution?"

This preoccupation, on the part of the teacher, with particle behaviour (which persisted throughout the lesson) might have been expected to influence pupils' thinking regarding the task, but in-group talk and action during this introductory time suggests pupil thinking to have been much closer to what they were doing. For example,

P_1 "What's the heading?"

P_2 "I'm going to burn my pen."

P_3 "You've filled it up too much (having difficulty in forcing the stopper into a full flask)."

(iii) <u>The experiment is designed with a purpose in mind</u>

To the curriculum writer (the task is a suggested activity in a standard curriculum guide to teachers) the experiment is designed to show change in a marked volume of water, i.e. expansion of liquids. This is achieved in the design by eliminating all possible opportunities for expansion except up the glass tube. The actions of pupils suggested that these design features were not appreciated (see next section).

(iv) <u>There are problems with carrying out the task</u>

The response of the pupil having difficulty in fitting the stopper into the flask full of water (see section (ii)) was to tip some of the water out. While this did make the job of fitting the stopper easy; unfortunately, it also meant that the glass tube was not below the surface of the water in the flask. They then started to heat the water. The teacher noticed another group who had also not met the expected design requirements and made a passing reference,

T "make sure that some of the green water can be seen up the glass tube."

This prompted the pupils in the observed group to again try and push the glass tube further through the stopper. However when this proved too difficult, they simply put the flask without the stopper back on the burner. By the time the teacher noticed what the group were doing, the water was boiling vigorously. In an attempt the recover the situation the teacher picked up the stopper and succeeded where the pupils had failed in pushing the glass tube further through the stopper and fitted it into the beaker; then said "right you can see where the water is now" and moved on. This action prompted P_4 to say, "Hey that's not gonna work because that's in the water". But already something had happened because steam in the tube had condensed and water was dripping out of the end of the plastic tubing.

P_4 "Look it's going down ... dripping."

P_5 "Sort of steam."

No one said anything about water levels.

(iv) <u>The experience has significance</u>

When water started dripping out of the plastic tubing the task was completed.

T "Hands up those people who have actually got water coming out into the beaker?"

P_2 "Yes, we have." (other groups also have their hands up)

T "Right, extinguish your burners please."

The teacher then initiated a brief discussion.

T "Can you explain why the water came up out of the tube?"

P_5 "Turns into a gas and has no choice but to go up that tube and when it goes down it's off the heat which makes it turn into a liquid and so it's just rolling down."

The only reference in this discussion to a change in water level was,

T "If the tube is in the water are you sure that gas would be going up the tube ... is gas going up the tube or is water going up the tube?"

P_3 "Water."

P "Gas." (from other group)

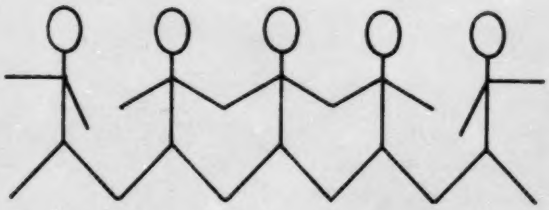
P_1 "Yeah, its gas."

The prevalence of the view showing that many pupils had used a situation where the tube was not in the liquid, appeared to cause the teacher to try to recover the situation by considering this apparently more common experience.

T "Right, correct ... O.K. That tube is fairly cold on the outside, once the water vapour hits the side of the tube ... it recondenses into water which comes out the end."

This sudden and unstated shift by the teacher away from the initial focus of the task appeared to leave pupils in the dark regarding the appropriateness of their perceptions.

At this point in the lesson the teacher used volunteer pupils to model this evaporation event. Five pupils were asked to stand in a line at the front of the class with their adjacent feet touching and with the middle pupil holding the nearest hand of the pupils on each side. The pupils were instructed to wriggle vigorously while the teacher talked.



T Right, stand in a line and jostle ... as the water heats more and more they start wriggling and moving a lot faster ... so people in the middle ... middle three start wriggling as fast as you can ... what's going to happen to the people at the ends?"

T (no one answers and nothing happens) Come on you people start <u>really</u> moving."

P "They smack off."

T. "(ignores comment) You are not meant to be moving - just stand still at the ends ... come on good shoves from the middle as you are getting hotter and hotter."

(one end pupil stumbles away)

T "Right ... O.K. one ends fallen off ... and that's what happens to the particles in the liquid ... sit down you didn't really do that very well ... right, as heat is applied the particles start wriggling and jiggling around ... and they jiggle the top particles of the liquid up in the form of a gas and it goes up the tube ... it recondenses and then it comes out the end."

The class were then instructed to

T "Write your observations and explain them by talking about particles ... I want you to explain what happened inside the water in terms of particles as heat was applied ... I expect to see diagrams explaining and showing particles and what happens."

That the experience had significance relating to particle behaviour was clear in the mind of the teacher - what were the pupils saying and doing?

P_1 "What do we do?"

P_2 "How do you spell 'gauze' ... here it is (finds word in a diagram of an earlier investigation) G..A..U..Z..E."

P_3 "Equipment is on the board."

P_2 "I know."

P_1 "I missed out gauze, burner and tripod ... how do you spell gauze?"

P_2 "G..A..U..Z..E."

P_3 "Look at the board."

P_4 "That there is called tripod, that there is gauze, that's the ..."

P_2 "Burner."

P_1 "No, t at's the burner ... that's the glass (burner cover)."

T "(interrupting) I've written a few words on the board that might help you with your write-up ... evaporates, recondenses and vigorous ... particles move in a vigorous fashion so that they were able to lift off the top of the solution."

P_4 "That glass thing that you put on ..."

P_3 "It's a rubber stopper."

P_4 "(writes label) Rubber stopper."

P_3 (writes subheading conclusion and after it 'we found that when we put the coloured water on the burner it made air bubbles')

P_1 & P_2 (copy P_3's statement into their exercise books when P_3 isn't looking - then close their books)

(v) Significance of outcomes in terms of children's views

In this lesson, the preoccupation of the teacher with a particular aspect of science theory (particle behaviour) was obvious. On the other hand, the concern of the pupils for the immediate situation (what they were doing and what was happening) was equally apparent. This was really two lessons.

What about pupils' views of some of the basic phenomena and events involved in the lesson? The example below is part of a conversation similar to a number held with individual pupils after the lesson.

P "When water is boiled it evaporates - turns into gases and goes off from there and turns into air."

P "The heat is sort of like ... pushing out all these little ... mmm gas ..."

O "The gas is in the water?"

P "I think they are in the water - when it gets heated ... they come out."

O "The gas ... has that anything to do with water or what?"

P "It's in the water."

O "It's not water?"

P "No."

End of the lesson conversation with the teacher revealed some dissatisfaction with aspects of the lesson and the unit of work.

T "I'm getting browned off with this unit - the equipment is so grotty - none of the tubes were clean ... it's such a hassle to set up so many groups."

However, in terms of the views that pupils took from the lesson (and the series of lessons), the comment below shows just how far away from where pupils actually are, the perceptions of a teacher with a strong content focus can be.

T "I think the concepts are getting a bit thrashed ... but actually it's all right - I think they are understanding it, but I think the interest isn't there as much as it was."

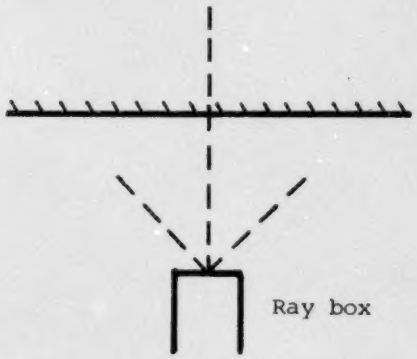
APPENDIX B: An attempt to get a particular outcome

Two girls apparently following instructions in a text book used a light ray projected from a ray box to investigate the nature of reflection in a plane mirror.

(i) Pupils' perceptions of the task

P_1 to observer "We have got to do this ... do it straight (project a ray at right angles onto the mirror) then you do a dotted line down here (marking the position of the ray) and then you've got to go like that (shift the mirror, keeping it at right angles to the projected ray, toward the ray box) and you have to see how many rays of light come off it ... like there is one there, one there and one there ... there should be three ... wait a minute."

(this strategy allows two rays produced by internal reflection in the ray box to be seen and it is these rays that the pupils identify as the expected rays and mark on their diagram (see below).)



(ii) Pupils perceptions of significance of outcomes achieved

O "I tried to draw what you had done (shows diagram above) I think you drew it like that (yeah) ... these rays (other than the one which strikes the mirror at right angles) where did they start - at the ray box or at the mirror?"

P "I'm not too sure ... I think they must start there (indicating the ray box) because when the mirror comes down that one is only there and then it starts coming out ... but the mirror made them."

O "If you didn't have the mirror would you get these lines?"

P "No - you'd only get that one line (the original ray)."

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